EFFECTS OF COMPENSATORY GAIN ON SUCCESS OF A 7-DAY CO-SYNC+CIDR ARTIFICIAL INSEMINATION PROTOCOL IN BEEF HEIFERS

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ABSTRACT

Angus heifers born in the spring of 2014 (n=38) were used to evaluate the effects of compensatory gain on the pregnancy status using a 7-day Co-Sync+CIDR® estrous synchronization protocol followed by a fixed-timed artificial insemination (FTAI) procedure. The heifers that were kept at the Management Instruction and Research Center (MIR group) were managed to a limited level of nutrient availability and experienced limited growth rate after weaning. Then the MIR group was placed in feeding pens to obtain an accelerated rate of gain to capture the compensatory gain phenomenon. Heifers concurrently managed at a collaborator herd in Fredericksburg (FRED group) were allowed access to oat forage, self-limiting supplementation, and free choice sorghum hay through the entirety of the project to suffice nutrient demands, not limiting growth rate. It was observed that even though differences in growth rate were significant, there was no difference in the pregnancy status from the FTAI.

TABLE OF CONTENTS

LIST OF TABLES

Page

LIST OF FIGURES

INTRODUCTION

Development of replacement heifers is a critical component for the beef cattle industry. It is critical because replacement heifers are still growing, allocating nutrients to maintain their own body condition, all the while trying to conceive and calve by the time they are 2 years of age. Heifers that conceive early in their first breeding season will calve earlier in the calving season and wean more calves that are heavier during their lifetime (Lesmeister et al., 1973).

Fixed-timed artificial insemination (FTAI) can be used to influence heifers to breed earlier in the breeding season, calve earlier in the calving season, and therefore provide additional days to rebreed for a second parity. Fixed-timed AI is designed to control the ovulation timing in heifers and eliminate the need of estrus detection (Hall et al., 2009). Pregnancy rates have been observed in beef heifers that were synchronized with a 7-day CIDR protocol and reported to be 43%-60% (Leitman et al., 2008). Because estrus detection in replacement heifers can be inconsistent and time consuming, the use of FTAI is an enticing option that producers can use to minimize time requirements, maintain reproductive efficiency, and integrate superior genetics.

Another important aspect of developing replacement heifers is managing them to an appropriate weight that is heavy enough to allow them to reach puberty while maintaining additional growth prior to the calving season. During the last decade, research has compared traditional more intensive systems of heifer development with more extensive systems using less feed and relying on compensatory gain (Parish, 2010). Compensatory growth is greater

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Journal of Animal Science

than expected weight gain following an extended period of slow growth or weight loss due to restricted nutrition (Carstens et al., 1989).Because reproductive efficiency and success are dependent on nutrient availability, producers can potentially alter the growth trajectory of growing heifers through compensatory gain in order to achieve optimum levels of reproductive success without the excessive financial burden caused by nutritional programs that are often required to maximize FTAI results.

The objective of this study is to investigate the effects of nutritional management on the success rate of timed artificial insemination, by evaluating the effects of compensatory gain on the pregnancy status of Angus heifers using a 7-day Co-Sync+ Controlled internal drug release (CIDR®) timed artificial insemination procedure.

LITERATURE REVIEW

The most important factors affecting the financial viability of a cow-calf enterprise are reproduction and nutrition. Bellows et al. (2002) estimated that reproductive diseases and maintenance of adequate body condition can cost beef cattle producers $441 to $502 million in lost income annually. Environmental cues that influence reproduction as well as nutrition variables should be given the largest amount of attention because producers can control the nutritional input in their herds.

Growing Heifer Management Strategies

An important goal for beef cattle management programs is to develop replacement heifers so that they can conceive by 14-16 months of age, calve when they are 2 years of age, calve unassisted, and breed back early for their second calf. Nutritional management can have an influence on the age and (or) weight in which puberty can occur. Reduction in age of puberty can be achieved by short-term feeding of high concentrate diets compared with feeding supplements to heifers grazing low quality roughage (Marston et al., 1995). Heifers that are on a low plane of nutrition, during the pre-pubertal term, can potentially limit the development of the reproductive system and slow the growth rate of developing heifers (Patterson et al., 1992). Therefore, timing of precipitation, forage quality and growth pattern in regards to the time of the breeding season may alter or enhance the reproductive performance of heifers due to an energy restricted (Endecott et al., 2012). Improving the nutritional plane during post-weaning and through the pre-breeding phases of development has resulted in acceptable conception rates and an increase in calf production, however, this required greater nutrition expenditure (Patterson et al., 1992).

Allowing heifers to make a rapid rate of weight gain during their last 3 months of breeding may decrease the feed cost through maintenance, due to lighter weight heifers in the early post-weaning period, and her potential to experience compensatory gain prior to breeding. Compensatory gain is a faster than normal rate of gain after feed has been restricted (Parish, 2010). The number of days being restricted of nutrients has an effect on compensation percentages as longer restrictions will decrease compensatory gain. The age of an animal when placed on feed can affect feed intake as well, as an increase in feed consumption by cattle experiencing compensatory growth has been observed (NRC, 2000). There was a reduced form of compensatory gain for calves that become restricted at an age less than 7 mo. When growth restriction is moderate, the catch up growth rate increases during the first month and can reach a maximum of 2kg/d in cattle. The period of elevated growth rate typically lasts for one additional month before it normalizes (Hornick et al., 2000).

Bagley (1993) observed that restriction in protein intake leads to reduced performance, which is more difficult to overcome than energy restriction which can ultimately reduce gain in calves. Beef animals have the ability to use the compensatory gain phenomenon to gain weight rapidly and efficiently (Bagley, 1993). The extent of the catch up growth can be known as “compensatory index” which is calculated as the ratio of the difference between weight variation at the end of restricted and compensatory growth periods to the variation at the end of the restricted growth alone (Hornick et al., 2000). This will allow producers to limit supplementation providing an opportunity to decrease cost of feed (Funston et al., 2011). Therefore, the compensatory body weight (BW) gain period for restricted growth heifers may be extremely important to her overall lifetime earning potential while in production (Endecott et al., 2012).

In general, it was traditionally accepted that heifers are expected to attain puberty when they have achieved approximately 60 percent of their mature BW (Funston et al., 2011). Body weight is a useful tool for predicating puberty and ensuring high fertility potential in growing heifers (Bagley, 1993). In the past decade, research has compared traditional, more intensive systems with a more extensive system with less feed and developmental inputs. Endecott et al., (2012) observed that developing heifers to a lighter BW that is 50 to 57 percent of mature BW compared to 60 to 65 percent mature BW not only reduced development costs, but also did not impair reproductive performance. Highest BW gain should not be the major goal in heifer development programs. Producers should strive for a functional, low-cost program that results in a pregnant heifer (Funston et al., 2011).

Managing the estrous cycle in breeding heifers one heat cycle earlier than the mature cow herd allows producers to concentrate available labor on heifer calving efforts (Larson, 2007). An added benefit of replacements that calve 3-4 weeks before a producer’s mature herd is the additional time for first calf heifers to return to estrus and conceive within the same time frame as the mature cow herd as second calf females and beyond (Bagley, 1993). Date of calving for first calf heifers may also have long-term impact on cow longevity and productivity. Calving later in year one increases the chances of late calving heifers to calve later the next year or not conceive (Endecott et al., 2012).

Beef Cow Longevity

The growth and development of genetically superior heifers from birth through the time they enter the cow herd is the primary factor for the overall efficiency of replacement management in a cow-calf system. In cattle herds, mature cows will leave the herd for different reasons such as, old age, failure to rebreed, poor performance, disease, health/physical problems, or death. The replacement heifers are necessary to maintain the producers herd size and to create the opportunity for improving and altering the genetics of that herd (Bagley, 1993). Longevity has a relatively low heritability; therefore, heifer development and other management strategies have a greater potential to impact cow retention in cattle herds, although limited information exists about the impact of heifers' development strategies on cow longevity (Speakman and Hambly, 2007).

Longevity is one of the most economically relevant traits for a beef cow. Increasing the longevity of mature, productive females reduces the annual production costs associated with raising replacement heifers, increases the number of prime age highly productive mature cows, and reduces the number of non-producing cows that are culled annually (Rogers et al., 2003). As producers have the ability to modify the time of ovulation and conception of replacement heifers through fixed-time artificial insemination (FTAI), it seems plausible to enhance cow longevity by influencing a higher proportion of replacement females to calve earlier in the calving season due to successful AI conception.

Additional Production Body Weight Measures

There has been a change overtime that resulted from 1) a shift from calving heifers at 3 years of age to calving at 2 years of age and subsequent selection pressure for decreased age at puberty, 2) the association between scrotal circumference overtime from several breed associations, and 3) perhaps a change in fertility of pubertal estrus compared with subsequent estrous cycles (Endecott et al., 2012). In addition to measures of body weight, body condition scores (BCS) can also be used to asses metabolic status and reproductive activity. Body condition scores are visual assessments of adipose tissue, ranging on a scale of 1 to 9, 1 representing the extreme emaciated and 9 is extreme obese (Wetteman et al., 1982). Cows that calve with a BCS ≥ 5 tend to have shorter postpartum intervals compared to cows that calve with a BCS ≤ 4. Bagley (1993) observed heifers calving with a BCS ≤ 4 had conception rates of 16% with postpartum intervals of 130d before returning to estrus as compared to heifers with BCS ≥ 5, where conception rates were 75% and postpartum intervals of 93d.

Weaning weight is another measure that can influence a cow's ability to stay in the herd. Genetic variances aside, cows that are able to calve earlier, tend to wean heavier calves as these calves have a longer period of growth before the common weaning date. This is also observed in heifers that ultimately end up in the same management programs as mature cows. Lesmeister et al., (1973) observed that heifers that calve earlier with their first calf tend to subsequently wean heavier calves throughout their lifetime. The primary factor involving the profitability of many cow-calf production enterprises is weaning a live calf.

Reproduction Management

Heifers reach puberty when they are able to express estrous behavior and ovulate a fertile oocyte. An oocyte is a cell in an ovary that undergoes meiotic division to form an ovum. The neuroendocrine system is maturing that induces maturation and ovulation of the 1^{st} oocyte, hormonal changes induce the first expression of behavioral estrus, and is the result of a gradual increase in gonadotropic activity which involves luteinizing hormone

(LH) and follicle stimulating hormone (FSH) activity. The increase of gonadotropic activity near the time of puberty is going to cause a decrease negative feedback of estradiol on the hypothalamic secretion of gonadotropin-releasing hormone (GnRH) (Larson, 2007). When puberty approaches, there is an increase frequency of LH pulses that results in the increase secretion of LH; this will enhance the development of ovarian follicles that will produce enough estradiol that induces behavioral estrus and a preovulatory surge of gonadotropins. Follicular development that has a wave like pattern may be detected as early as two weeks of age in heifers and the duration of follicular wave and the maximum diameter of the dominant follicles will increase with age through puberty (Larson, 2007).

There are two approaches to synchronizing bovine follicular waves that includes 1) prolonging the lifespan of the dominant follicle or 2) ovulating or initiating the dominant follicle to initiate a new follicular wave (Perry, 2012). Dominant ovulatory size follicles develop in waves during both the follicular and luteal phase of the estrous cycle. The estrous cycle consists of 2 or 3 follicular waves. The follicle is stimulated on each ovary by the increase of FSH (Perry, 2012). A selection process occurs in which one follicle is recruited to grow and become the dominant follicle. A decrease of FSH makes the smaller follicles unable to grow and allows the dominant follicle to continue and be less dependent on FSH and more on LH (Perry, 2012).

Underfeeding heifers/cows will have an extended period of ovarian inactivity, inhibition of gonadotropin secretion, initiation of follicular development, occurrence of estrus with ovulation, and adequate luteal lifespan for maternal recognition of pregnancy (Randel, 1990). Cattle that are on a lower plane of nutrition will have lower profiles of LH release than cattle on a higher plane of nutrition (Randel, 1990). The decrease in BCS, BW, and (or) feed intake in cattle results in reduced growth and persistence of dominant follicles. But an increase feed intake in BW and BCS of undernourished cattle results in increased growth and persistence of dominant follicles (Bossis et al., 2000). The ability to monitor follicular growth is necessary for the development to synchronize both follicular waves and luteal regression to achieve pregnancy success to FTAI (Perry, 2012).

The development of protocols for artificial insemination in beef cows and heifers at a FTAI has shown results of high fertility and a dramatic increase in the adoption of AI in beef herds. Fixed timed artificial insemination protocols were created so that cows and heifers could be inseminated without going through estrus detection. Presynchronization allows more heifers to be at an estrous cycle stage that will be more likely to respond to a GnRH injection and results in a new follicular wave. After GnRH induced ovulation a new follicular wave is initiated approximately 1.6 d later. The ability of GnRH to induce ovulation and initiate a new follicular wave is dependent on the stage of the estrous cycle. Heifers that have a CIDR inserted vaginal 48h before an injection of GnRH had a greater concentration of progesterone at GnRH administration, a reduced LH surge, and reduced ovulation rates compared with heifers that had CIDR inserted vaginal at time of GnRH or 6h after GnRH administration (Perry, 2012). More heifers ovulated in response to a GnRH injection compared to heifers not presynchronized and presynchronization increased pregnancy success to FTAI in beef heifers (Perry, 2012).The ability to induce ovulation with GnRH at time of FTAI increases ovulatory responses.

Pregnancy success was greater among heifers that exhibited estrus within 24h of FTAI compared with heifer that did not exhibit estrus (Perry, 2012). Estrus synchronization protocols, that result in highly synchronized estrus and ovulation, reduce the time and labor associated with estrus detection, thereby making estrus synchronization and AI more feasible to a broader range of producers. An increased estrous response, improved synchrony of estrus, and greater FTAI pregnancy rates was observed in beef heifers that were synchronized with a long-term 14 day CIDR protocol compared with a short-term 7 day CIDR protocol (Leitman et al., 2008).

Overall, because reproductive efficiency and success are dependent on nutrient availability, producers can alter the growth of growing heifers through compensatory gain in order to achieve optimum levels of reproductive success without the excessive financial burden caused by nutritional programs and also eliminate the need of estrus detection that is often required to maximize artificial insemination results by using FTAI. The objective of this study is to investigate the effects of nutritional management on the success rate of timed artificial insemination, by evaluating the effects of compensatory gain on the pregnancy status of Angus heifers using a 7 day Co Sync+CIDR® timed artificial insemination procedure.

MATERIALS AND METHODS

All methods were approved by the Angelo State University (ASU) Institutional Animal Care and Use Committee Protocol # 14-05. Spring born Angus heifers were used for this study. All heifers originated from the Angelo State University Angus herd or a collaborator herd that utilizes genetics from the Angelo State University Angus herd. Mention of trade names is provided for protocol descriptions and does not constitute product endorsement over other similar products.

All heifers in this study were weaned at day -174 and given vaccinations consistent with ASU cattle health protocols. Heifers managed at the Management Instruction and Research center (MIR) (n=18), were turned out on native pasture with minimal supplementation from day -145 to day -41 and were managed to maintain .23 to .32 kg per day average daily gain (ADG). From day -41 to day 0, MIR heifers were put in feeding pens with *ad libitum* access to a diet that was designed to allow them to gain approximately 1.81 kg per day. The ingredients and percentages of ration components are presented in Table1 and nutrient composition of the maintenance ration is presented in Table 2.

Table 1. Ingredients and Percentages of ASU Maintenance Ration

Ingredient	% in Ration
Corn	25.00%
Corn Gluten Feed Pellet	15.00%
Cottonseed Hulls	27.00%
Alfalfa Pellets	27.00%
Molasses	4.00%
ASU RAM PREMIX[1]	2.00%

[1]Premix: 17.5 - 19% Ca, 18.1 – 20.6% NaCl, 1075 ppm Mn, 1780 ppm Zn, 3.95 ppm Se, 89,187.09 IU/kg Vitamin A, 29,728.03 ppm Vitamin D, 493.83 ppm Vitamin E.

Table 2. Diet composition of ASU Maintenance Ration

Nutrient, DM	ASU Maintenance Ration
NEm Mcal/CWT	72
NEg Mcal/CWT	40
TDN %	64.87
Crude Fat	2.97
ADF	26.71
NDF	42.53
Crude Protein	14.84
Calcium	0.94
Phosphorus	0.38

Heifers managed at the collaborator herd in Fredericksburg (FRED) (n=20) were rotated through three, 16.5 hectare oat paddocks in a low intensity, long duration procedure and were supplemented with a commercially available free choice, self-limiting ration supplementation (Purina Accuration Forage Supplementor) and free choice sorghum hay from day -145 to day 0 and gained roughly .91 kg – 1.13kg per day. The guaranteed analysis of this supplement is presented in Table 3.

Table 3. Guaranteed Analysis for Purina Accuration Forage Supplementor

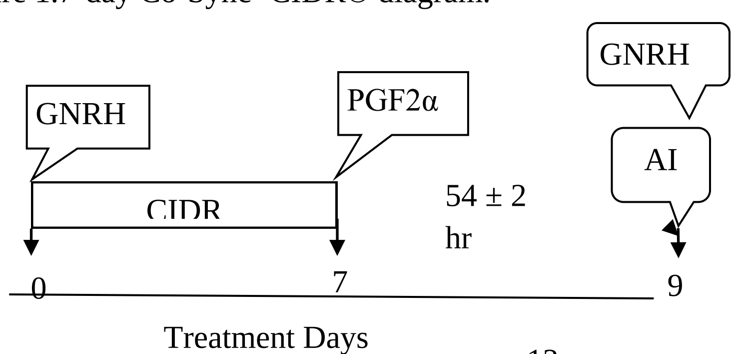
Nutrient, DM	Ration
Crude Protein (min)	33.0%
Crude Fat (min)	8.0%
Crude Fiber (max)	5.0%
Calcium (min)	1.5%
Calcium (max)	2.0%
Phosphorus (min)	1.0%
Salt (min)	4.5%
Salt (max)	5.5%
Potassium (min)	0.3%
Selenium (min)	1.0ppm
Vitamin A (min)	12,000 IU/Ib

Synchronization Protocols

The protocol that was used in this study for all heifers was the 7 day Co-Sync+CIDR®. The 7 day Co-Sync+CIDR® consisted of an injection of Gonadotropin-releasing hormone (GnRH) and a controlled internal drug release (CIDR), which is a T-shape vaginal insert containing progesterone that is approved for use of estrus synchronization in cattle (Mapletoft et al., 2002) on day 0. On day 7, the CIDR was removed and an injection of Prostaglandin (PGF2α) was given. On day 9 all heifers were bred via artificial insemination (AI) by certified AI technicians and a second injection of GnRH was administered following AI. The GnRH injection causes the release of luteinizing hormones (LH) and follicle stimulating hormones (FSH) from the anterior pituitary gland. These hormones target the ovary, which grows the follicles that ultimately produces the egg. Prostaglandins regulate the heifer's estrous cycle due to luteolysis or regression of the corpus luteum (CL) (Rasby and Funston, 2010).

Figure 1 is a diagram description of the Co-Sync+CIDR® protocol used in this trail and Cystorelin® was used as the GnRH source with Lutalyse® being used as PGF2α source in this project. Products were administered at dosage levels in accordance to product label instruction.

Figure 1.7-day Co-Sync+CIDR® diagram.



On day 58 a 5mL blood sample, via jugular vein, was collected and shipped to Circle H laboratory (Dalhart, TX) that measured the presence of Pregnancy-Specific Protein B (PSPB) to determine the pregnancy status of the fixed-time artificial insemination using the bioPRYN ELISA kit. Test levels higher than 0.210 reflect animals that have a 93%-95% confidence level as being pregnant as compared to known non-pregnant animals. Levels lower than 0.135 reflect animals that have a 99.9% confidence level as being confirmed as not pregnant or open (BioTracking, 2016). A visual description of procedures and timing is presented in Table 4.

Table 4. Day of project and procedures.

Day	Procedure
-174	Wean, 4-way BRD vaccinate, trichguard vaccine, 7-way clostridial booster vaccine
-145	4-way BRD vaccine booster, trichguard vaccine booster, brucellosis vaccination, freeze brand and turn out
-41	Weigh all heifers and MIR heifers back on maintenance ration
0	CIDR in + 1st GNRH[1] injection
7	CIDR OUT + PGF2α[2] injection
9	AI all heifers + 2nd GNRH injection
58	Biopryn sample

[1]Cystorelin® by Merial
[2]Lutalyse® by Zoetis

Statistical Analysis

Mixed model procedures of SAS (SAS Inst. Inc., Cary, NC) were used to analyze body weight differences with a model that includes the fixed effects of day (-145, -41, 0), diet treatment (FRED and MIR), day -174 as a covariate, and two-factor interactions. These models were measured as repeated measures with a first order autoregressive covariance structure. Average daily gain was analyzed with a similar model but excluded the repeated measure statements. Frequency distribution of pregnancy occurrences was analyzed via Chi-square test being examined.

RESULTS

The summary statistics of this data is presented in Table 5.

Table 5. Summary Statistics of Variables Measured

Variable	n	Mean	Minimum	Maximum	Standard Deviation	Coeff. of Variation
[1]Period 1 ADG, in kgs	39	0.48	-0.06	1.05	0.3	0.63
[2]Period 2 ADG, in kgs	39	1.4	0.6	2.04	0.44	0.31
Day -145 Weight, in kgs	39	341.93	276.24	390.09	30	0.09
Day -41 Weight, in kgs	39	405.36	330.22	458.13	35.23	0.09
Day 0 Weight, in kgs	39	472.51	404.61	551.12	32.06	0.07

[1]day -145 to day -41; [2]day -41 to day 0

Variation in the variables of interest frequently yielded significant results in this study. Beginning with the main effects of diet and day accounting for differences in these data. Variation due to the diet is presented in Figure 2. The mean weight of all days measured in the FRED treatment group was 414.32 kg which is greater than the mean weight if the MIR treatment group heifers which were 397.59 kg for all days measured ($P \leq 0.05$).

Figure 2. Main effect of diet treatment on weight, in kgs.

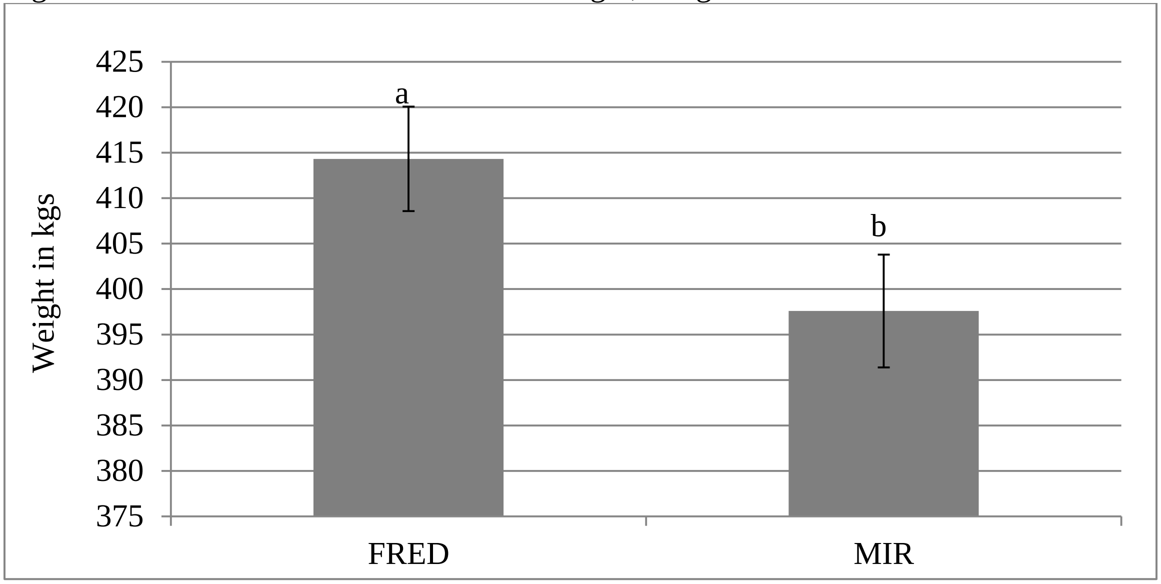


Figure 2. Least squares means of weight in kgs due to the main effect of diet.
[a,b] subscripts differ ($P \leq 0.05$)

Variation due to the main effect of day, regardless of diet, is presented in Figure 3 and represents an increasing pattern of growth performance for all heifers in this study with all days being different ($P \leq 0.05$).

Figure 3. Main effect of day on weight, in kgs

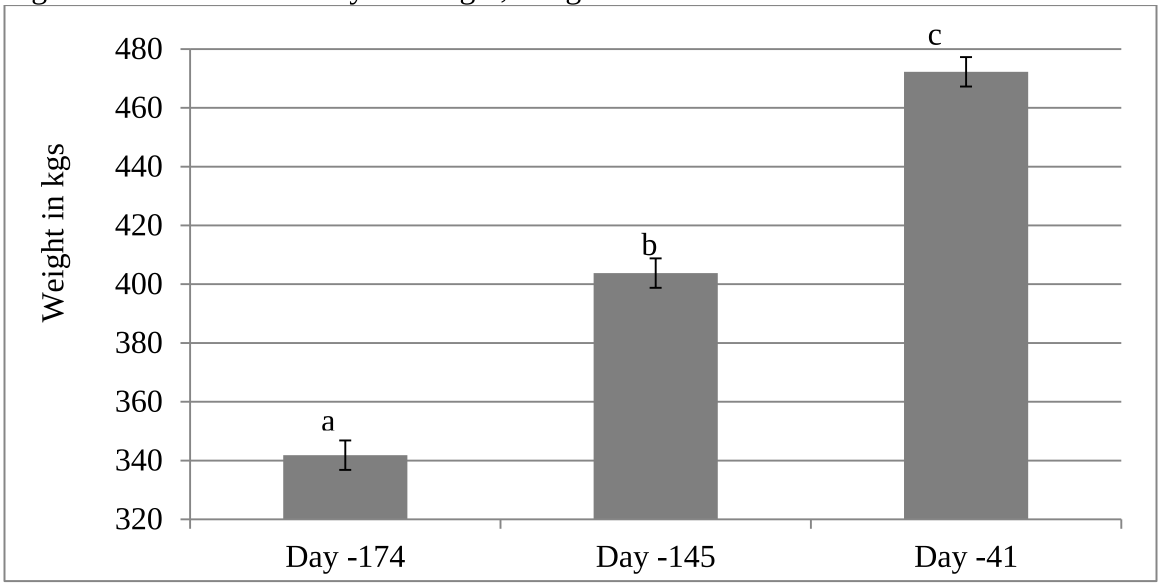


Figure 3. Least squares means of weight in kgs across days.
[abc]subscripts differ ($P \leq 0.0001$)

While weight gain has been shown to be a reliable tool of estimating puberty and fertility in beef heifers (Bagely, 1993), the aim of this study was to determine if the timing of weight gain impacted the results of a standard estrous synchronization (ES) and fixed-timed artificial insemination (FTAI) event. Figure 4 presents the interacting term of diet × day and reflects evidence of the compensatory gain event in the MIR raised heifers from day -41 through day 0.

Figure 4. Main effect of diet × day on weight in kgs.

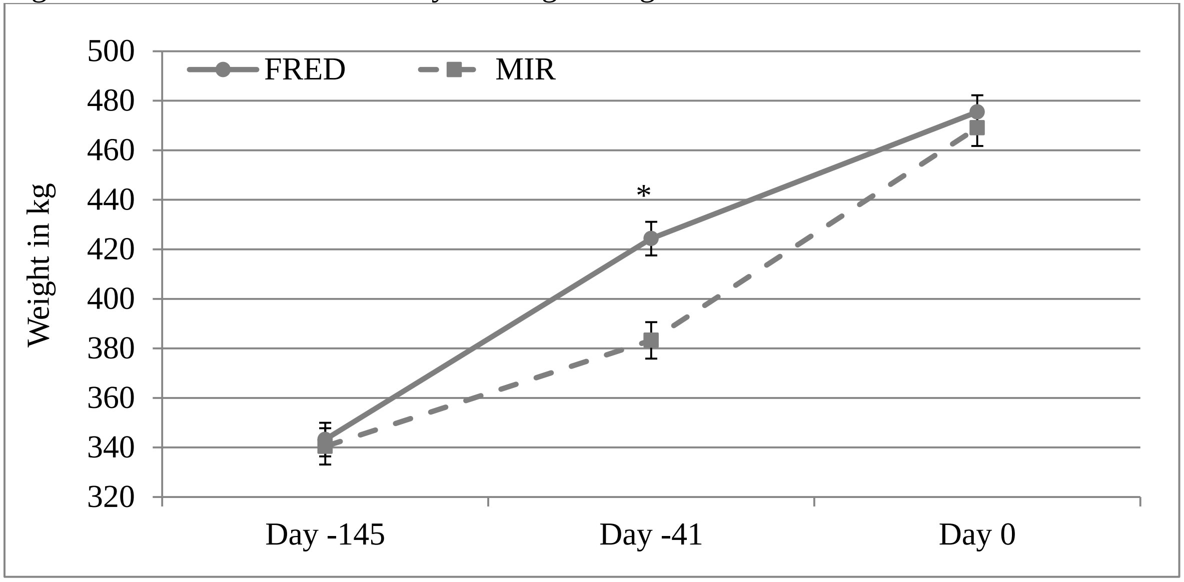


Figure 4. Least squares means of weight in kgs due to the diet × day interaction.
* Indicates weight differs (*P* < 0.0001) between treatment group within day

No differences between the FRED and MIR groups were observed during day -145 or at day 0. At day -41 however, weights between the diet treatment groups differed ($P \leq 0.0001$). The variation due to application diet treatment where the FRED group was heavier and not restricted while the MIR group had depress weight gain due to limited forage nutrients availability from day -145 through day -41.

In this study, forage availability was not limiting in the FRED group at any point in the trail or the MIR group during the grazing period, implying that differences in growth from day -145 and day -41 is due to forage nutrient composition, and level of supplementation. The MIR heifers were program supplemented with an infrequent supplementation protocol to maintain native range dry matter intake (DMI) at a level consistent to restrict gain to approximately 0.23kg/day. In contrast, the FRED group consumed winter oat forages with self-limiting supplementation and additional ad libitum sorghum hay, suggesting that FRED treatment cattle consumed sufficient nutrient content for sustained growth rate without restricted nutrient availability.

Additional evidence of a compensatory gain phenomenon in the MIR heifers is evident in Figure 5.

Figure 5. Main effect of diet on ADG in kgs within each ADG period.

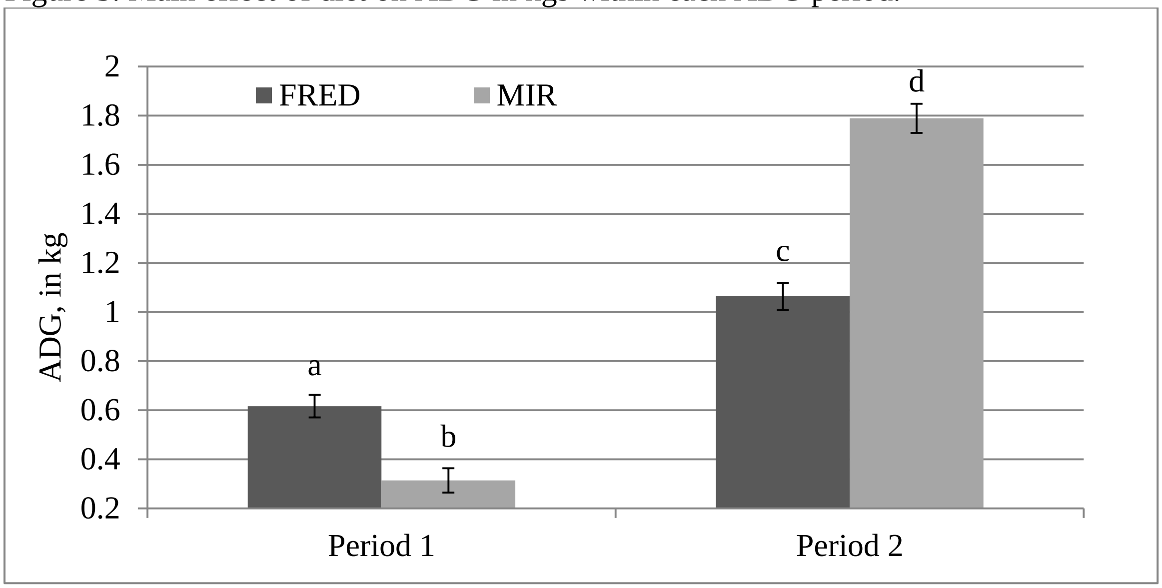


Figure 5. Least squares means of ADG in kgs due to diet treatment within period.
Period 1: Day -145 to Day -41; Period 2: Day -41 to Day 0
[abcd] subscripts differ ($P \leq 0.05$)

The ADG of FRED females was greater than the MIR females in period 1 ($P \leq 0.0001$). But in period 2 the mean ADG of the MIR heifers was 0.72 kg greater than the FRED heifers ($P \leq 0.0001$). This greater ADG reflects the compensatory gain after the restriction period similar to (Roberts et al., 2009). At day -41 the MIR heifers were placed in feeding pens with ad libitum access to ASU maintenance ration (Table 1. and Table 2.) while the FRED cattle continued procedures of oat forage pasture rotation, free choice self-limiting accuration supplement, and ad libitum sorghum hay.

Pregnancy status from FTAI for the FRED and MIR heifers is presented in Table 6.

Table 6. FTAI Pregnancy Status

FTAI Pregnancy Status	FRED	MIR
Bred	10	7
Open	11	11
% Females pregnant from FTAI	47.62%	38.89%

No statistical difference in pregnancy status was observed from the χ^2 analysis in these data as per the bioPRYN ELISA results (*P*= 0.75). These results are consistent with Funston and Deutscher (2004) where it was observed that no differences in pregnancy status was detected in developing spring born heifers to a lighter percentage of mature body weight early in the development period and this resulted in a $22/head reduction in developmental costs in a pen feeding scenario in their report.

IMPLICATIONS

The summation of this project suggests that beef cattle producers can alter the growth rate trajectory or timing of growth of growing heifers through compensatory gain and still achieve reasonable levels of reproductive success using estrous synchronization and fixed-timed artificial insemination. To our knowledge, at the time of this report, this project would be the first to determine the effects of compensatory gain on heifer pregnancy from FTAI. While the scope of this study was not the financial viability of pre-breeding procedures, this data implies the potential to lower financial burden of developing heifers by using compensatory gain to cheapen the cost of gain, while not limiting the success rate of FTAI in yearling age beef heifers.

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